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The largest δ^{13}C excursion of Earth History: the late Neoproterozoic Khufai-Shuram boundary of Oman.

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The late Neoproterozoic period of Earth history was characterized by intense climatic oscillations that are commonly interpreted as snowball Earth events and correlated world wide by sharp negative δ^{13}C excursions. On top of a dated 800-825 Ma basement (Leather 2001), the Neoproterozoic stratigraphy of Oman contains two the record of two glacial epochs - the Ghubrah (dated 712 Ma; Leather 2001) and the Fiq formations (currently undated), separated by a major unconformity (Le Guerroué et al. 2005b) which seem to correlate well with the two 'global' Sturtian (700-750) and Marinoan (630-640) snowball Earth-type glacial epochs (Brasier et al. 2000; Allen et al. 2004; Le Guerroué et al. 2005b). A third younger glaciation (corresponding to the Varangerian glacial epoch; Halverson et al. in press) is supposed to have occurred after 600 Ma and possibly being as young as 580 Ma (Le Guerroué et al. 2005a). The fingerprint of this last glacial epoch, preserved on every continental fragment (proper equivalent are: Nama Group of Namibia; Wonoka Formation of Australia and Johnnie Formation of California; Le Guerroué et al. 2005a), the largest negative carbon isotopic excursion of earth history.

The Varangerian epoch is recorded in the overlying strata of the 1 km-thick Nafun Group of Oman. The Nafun Group is made of two siliciclastic-carbonate depositional cycles, comprising the Masirah Bay-Khufai formations and Shuram-Buah formations, and overlies the probable Marinoan-aged Fiq Formation and its cap carbonate (Allen et al. 2004; Le Guerroué et al. 2005b). The top of the Buah Formation, representing the end of Nafun deposition, is dated at c. 550 Ma (Cozzi and Al-Siyabi 2004), very close to the Precambrian-Cambrian boundary (542 Ma).

The Khufai-Shuram boundary is well exposed in the core of the Jabal Akhdar (northern Oman) and in the Huqf region of central Oman. In the former the outer ramp carbonates of the Khufai Formation are overlain by relatively deep marine red and brown siltstones and storm-generated sandstones interbedded with fine limestones. In the Huqf area, however, shallow-water inner ramp carbonates of the Khufai Formation are directly overlain by the storm-influenced reddish siltstones of the Shuram Formation.

Although the Khufai-Shuram boundary does not show evidence for glacial depositional settings, in both Jabal Akhdar and Huqf sections it records a large negative δ^{13}C excursion, with values dropping from around +4‰ at the top of the Khufai, to values of -12‰ at the base of the Shuram. This negative shift observed in the whole Oman, persists throughout the Shuram Formation and for most of the overlying Buah Formation, where only at the top positive values are finally reached (+2‰) (Cozzi and Al-Siyabi 2004; Le Guerroué et al. 2005a). The Khufai-Shuram boundary negative isotopic shift correlates well with other sections worldwide where the same isotopic pattern is found (Le Guerroué et al. 2005a). Most of these sections do not contain glacial diamictites nor cap carbonates associated with the negative shift. Therefore, the isotopically light Shuram Formation interval may correspond with a young (Varangerian) non-global glaciation, discarding any causal relationship between the negative δ^{13}C excursion and a snowball Earth event. At this time, the mechanism(s) capable of producing such dramatic changes in the C cycle are still an unresolved problem.

Detrital zircon analysis from north and east-central Oman shows zircon subpopulations characteristic of basement (800-820 Ma), and magmatic events coinciding with the Sturtian (Ghubrah Formation equivalent 710-730 Ma) and Marinoan glaciations (Fiq Formation equivalent 630-640 Ma). The youngest sub-population shows an average age of 609 Ma with grains as young as 590 Ma.. This age may be close to the depositional age of the Khufai-Shuram boundary and currently provides the best estimate of a maximum age for the large, possibly Varangerian, isotopic excursion.

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